# Visual Perception of Deaf Children to Inform Interaction of Tools for Literacy

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**Abstract.** The Deaf community has its own culture, a term applied to the social movement that holds Deafness to be a difference in human experience, rather than a disability. The disability view of Deafness has deprived the Deaf of natural language acquisition, which is crucial for intellectual development. Human-Computer Interaction should be held accountable to better understand the needs of the Deaf community to inform design. There is a lack of tools for visual literacy of the Deaf (i.e. a learning process for teaching to read based on image interpretations). This research proposes an online environment that educators and designers could use to evaluate visual characteristics of the Deaf. The environment contains four tests designed to assess visual perception and subjective preference. The case study within a classroom context validated the environment. Designers could use the results of their testing to inform design.

**Keywords:** Deaf culture, user-centered design, testing environment, visual perception.

## 1 Introduction

The Deaf community lives a historical period of affirmation of social rights that have been denied to them for over at least a hundred years. There are still many challenges surrounding the issue of social integration of the Deaf, along with the full acceptance of their rights and duties to effectively participate in society, and to fully exercise citizenship [7]. These challenges put in evidence the importance of computer research based on the needs and specificities of people. Particularly, for research that respects and takes into account Deaf people's differences.

90% of Deaf children are born to non-Deaf parents, with little to no exposure to natural language acquisition. Natural language and its acquisition has long been the subject of researches, which have proven its crucial role in intellectual development [7]. The gaps between the Deaf and her family due to lack of language leads to high levels of mental diseases later in life, a threat that is in direct relation to life and survival of the Deaf [11].

The Deaf have their own community, and Sign Language (SL) is the natural language of the Deaf: their tool for communication, knowledge creation and other

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aspects that are language-related. And SL is a major component of the Deaf culture: a term applied to the social movement that holds Deafness to be a difference in human experience, rather than a disability. SL is a complete linguistic system, or spatial-visual manner [2]. This characteristic lends itself important to the visual understanding of the world by the Deaf, and should be used in learning environments for Deaf children.

Human-Computer Interaction (HCI) has long established the responsibility to explore deeper into more complex features of users (e.g. culture). Technology should serve the needs of humans, not the other way around. Most educational experiences in school have not achieved the desired goal of adequately dealing with the learning and usage of SL and Portuguese: There is a lack of information on how the Deaf real needs are understood or taken into account; there is a lack of research on how these considerations should inform design. "The need is pressing […]" especially when our work extends into differing communities that are not our own [21].

The present study aims at bridging such gap by providing a computer environment, with four different tests, especially designed as per the characteristics of the Deaf, to help designers to better understand visual aspects of Deaf people. Educators and designers can use such tests to learn about the ways the Deaf perceive information.

Most studies on such topic are from behaviorist psychology, with little validation of ecological and social integration, and are not adequate to the specificities of the Deaf. This clinical view of the Deaf children put them and their parents through a lot of tests. It's sadly true that many children get traumatized. Thus, the user-centered approach geared towards the Deaf, used in the proposed environment, advances researches on tests to determine visual perception and cognitive abilities of the Deaf, by performing them in a ludic way.

## 2 Related Works – Theoretical Background

Members of the Deaf community, users of SL, tend to have a strong visual ability. There is a need for adequate instruments to help stakeholders in general, and educators of Deaf children in particular, to develop and deploy tools to research and understand information behavior of their student. The present section explores some considerations that will provide sound scientific base for the proposed environment of tests and its online environment.

The proposed testing environment draws much of its premises from the importance of the use of "visual" elements in teaching and learning for the Deaf. Bertin [3] classified the use of graphic visual elements in the representation of data and its relations, as applied to graphs and maps. The author emphasizes seven (7) variables, or visual attributes that are fundamental in any visual representation: color, shape, size, position, orientation, value and texture.

With regard to the relationship between Deafness and visual-cognitive skills, many authors indicate that the use of SL makes the Deaf have specific characteristics and strategies when certain visual aspects are analyzed, especially those considered as high-level face recognition [13] transformation, rotation and visualization in mental

representations [8], completeness gestalt [18 et al.], construction and transformation of objects [2], memory for simultaneously presented shapes [19]. Such evidences leads us to believe that the process of construction and manipulation of mental images by the Deaf have particular characteristics, that should be explored.

Parasnis et al. [15] also shows that Deafness itself is not conducive to differences in performance between Deaf and non-Deaf, which raises the idea that the use of SL is paramount to such differences, given the visual-spatial character of SL. As for the organization of visual elements, there are some evidences in [16] that the Deaf children perceive dominantly color over shape. However, it is important to note that some studies say that there was little knowledge about the visual process of the Deaf, then as well as today [4]. This research presupposes that the process of constructing and manipulating mental images by the Deaf seem to have differentiated characteristics. This follows the idea from reference [1] that mental images of a scene may have a greater influence on the user focal attention than the scene itself.

The proposed environment takes after User-Centered Design (UCD), which is "[…] concerned with the incorporation of user perspective in the software development process in order to achieve a usable system" [12:1]. There follows that "[…] the design should make use of the inherent characteristics of people and the natural world, to explore the natural relationships and natural constraints […]" [14: 222]. From the UCD perspective then, we have that the final product must assess and incorporate the perspective of the user. The proposed testing environment follows three essential requirements for computing environments that are to be effective and well accepted by the Deaf:

1. The user-system communication should happen in the native language of the user. In the case of the Deaf in SL and preferably with videos [10].
2. The video instruction must be shown by an interpreter fluent in SL and she should respect the rules of interpretation [5]. The proposed environment recorded the videos with an interpreter, fluent in SL, who conveyed ludic play tasks, and who congratulated the child after the execution of the tasks.
3. Try to keep the user's attention focused on the main screen [6].

The study of visual perception can use as a basis the principles of Gestalt. The so-called "Gestalt psychologists," based on a series of experiments, determined that there are certain constants responsible for how our internal forces act in relation to what we see [9]. These constants are: Unity (related to the shape); Segregation (the ability to recognize the units); Unification (visual cohesion as a function of greater balance and harmony); Closure (completudness); Continuity (sequence and fluidity); Proximity (elements close to each other tend to be seen together); Similarity (similar stimuli tend to group in unities) and Shape (image formation, balance, clarity and visual harmony).

## 3 Proposed Testing Environment

We seek to study the following visual variables: color, shape, size and the Deaf's subjective preferences for colors, in the school context. Additionally, the proposed environment aims to test such variables in a ludic context, in a playful manner, thus

distancing from the lab experimental protocols. Vigotsky [20] tells us that play is a crucial process in which one understands ideas, develops skills and participates in social roles; it helps to build a learning context, and increases motivation and involvement. Thus, the proposed environment was designed with emphasis on the ludic, in order to be more pleasurable, and not seem to be another "experiment".

The environment was implemented in HTML and tests were designed to work with low-end computers and slow Internet bandwidth, in order to be accessible to a larger number of Brazilian schools that have a varied computational resource. The testing environment is available at: http://pvtestes.c3sl.ufpr.br.

The proposed environment uses the many advantages provided by a remote, online access (low cost obtained by less impact of time, space and people constraints). Participation is individual. And basically, the environment requires two types of actors: teacher-evaluator and participating children, with the following profiles:

- ***Teacher-evaluator:*** elementary school teachers of the Brazilian public school system, with proficiency in Portuguese and little knowledge of SL.
- ***Child-participant:*** Deaf children whose first language is SL, from k to 5 elementary schools of the Brazilian public system.

The environment provides instruction through videos in SL and written Portuguese. Figure 1 shows a screenshot of the initial interface for the teacher-evaluator and the initial video welcomes the children, and invites them to play, by interacting with the environment and performing the tasks of the game.

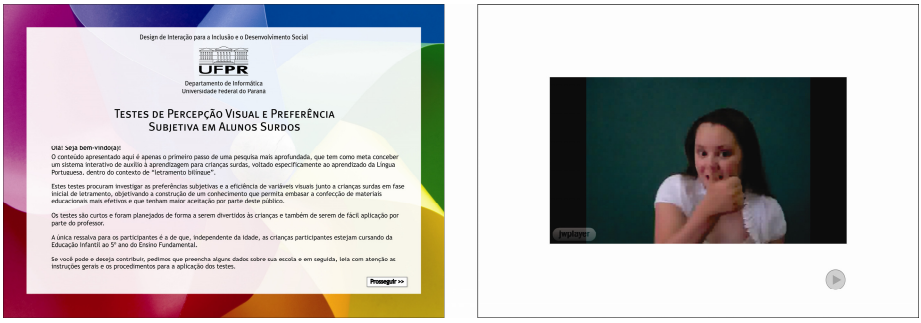


**Fig. 1.** Screenshot of "Welcome to the teacher-evaluator" and video for "Welcome to the child-participant"

The role of the teacher-evaluator is that of mediator, acting only when necessary. And the Deaf children are free to explore and perform the tasks (in a manner similar to the experimental learning paradigm from Schön [17]). The remainder of this section presents four tests (a, b, c and d) that can be found on the proposed environment.

***a) Test of perception: Color, Shape and Size - "Memory Game"***

*Objective:* to assess which of the visual variables (color, shape and size) was perceived "first", in the sense of being the first to be chosen.

*Background:* this test would yield the most preeminent variable. Therefore, such characteristic should be used to enhance the visibility of an element, within a system, that requires greater emphasis, when presented on the screen of interactive environments.
*Preparation:* 12 pairs of figures for the game were specially developed in order to evenly present the three variables, object of study, in detriment of other visual variables (Figure 2).

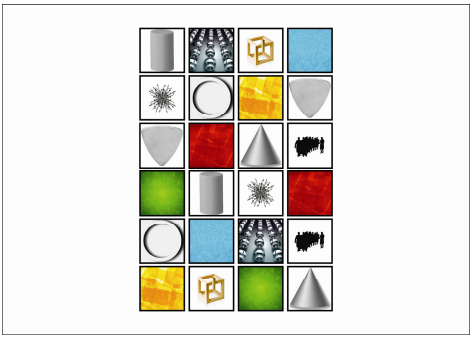

**Fig. 2.** Example configuration of the figures for the test "Memory Game"

*Procedures:* a video is played, with the SL interpreter inviting the child to play a memory game. The child is instructed to look at the images to try do memorize their position. The figures are shown during 10 seconds. Then the child starts to interact with the environment to start the game. The task required of the child is to select pairs of the images. A correct match would involve selection of a pair of the same characteristic (e.g. the cone – chosen by shape).
*Evaluation form:* the system stores the image that was selected in the first attempt; which image was selected in the first image pair hit (color, shape or size); how many attempts the participant needed to hit the first pair; the time spent for each correct answer and time taken to complete the game.
*Duration:* 5 minutes for each game.

***b) Test of color perception: "Seven Errors Game"***

*Objective:* evaluate the efficiency of the variable color to identify peculiarities in figures.
*Background:* results may give insight as to the use of color in visual presentation of detailed information.

*Preparation:* in order to maintain the same cognitive effort for the game in black and white and color, the same figure was used for both situations; but the errors were arranged differently (Figure 3).

*Procedures:* a video with a SL interpreter will explain to the child that she must find the 7 errors in the two figures (taken from comic books by Maurício de Souza).

**Fig. 3.** "Seven Errors Game" on Colors and B&W

The system presents the child with the number of errors already found. The child will play both scenarios, in black and white and in color, presented in a random way.

*Evaluation form:* the system stores the time spent for each error encountered and total time spent in the activity.
*Duration:* 5 minutes for each game.

***c) Perception test: Color, Shape and Size - "Connect the Dots Game"***
*Objective:* "Gestalt similarity" concept is used here to asses which visual variable (color, shape or size) better serve as scaffold for the grouping of features in a picture.
*Background:* the results can help define which visual variable is more efficient for educational activities.
*Preparation:* the figures were drawn so that the child would connect the dots to form an image (of a butterfly, a vase and an apple. Three options are presented, one for each variable: shape, size or color (Figure 4).

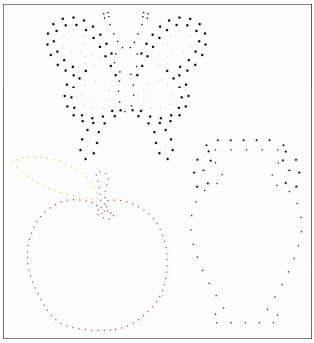

**Fig. 4.** Possible figures in the "Connect the Dots Game"

*Procedures:* a video with a SL interpreter will explain to the child that she should complete the figure by connecting dots. The video shows the SL sign of the figure and the child starts the game. The figures will be presented in random order. Having

completed 50% of the dots, an arrow will be shown, to allow the child to determine if the figure is completed, or if she desires to continue joining the dots until the end. Additionally, there is an "eraser" that allows the child to undo her drawing actions.
*Evaluation form:* the system stores the lines created; time spent for each figure and the figures that the participant chose to complete (e.g. the apple (color, shape or size), the butterfly (color, shape or size) or vase (color, shape or size). Additionally, it stores whether the child used the eraser to back an action (Figure5).
*Duration:* 5 minutes for each figure.

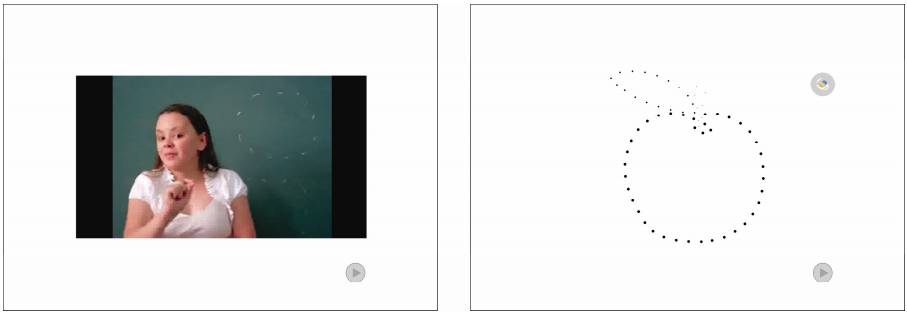

**Fig. 5.** Procedure in video and example of possible figure

***d) Subjective preferences test: Variable Color***
*Objective:* assess the subjective preference of color by the Deaf participants (i.e. to find out whether there is a pattern which indicates a subjective preference of color and how it can be correlated with the characteristics of the subjects).
*Background:* any preferences for certain colors can base the creation of materials for specific segments.
*Procedures:* a video with a SL interpreter will presents the child with 6 balloons, each of a different color (red, green, blue, yellow, orange and purple). Then the child is asked to choose her favorite color. The order of the colors is changed randomly (Figure 6).
*Evaluation form:* the system records the color of choice.
*Duration:* 1 minute.

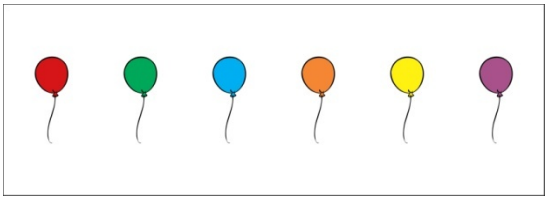

**Fig. 6.** Color sequence of balloons offered to children

### 3.1 Case Study

The initial validation of a prototype of the environment took place in an elementary school, over a period of 4 hours. Bilingual teachers were present, to act as teacher-evaluators. 15 Deaf children, of both genders, aged between 5 and 14 years of age, from k to 5, proficient in SL, were the subjects. The wide range of age is due to the fact that most Deaf children enter school only later in life. The application of the tests generated some interesting results, which are presented hereafter.

***a) Test of perception - Color, Shape and Size - "Memory Game":*** results obtained for this task show that elements with color (42.86%) and size (35.71%) variations were most popular between children. This result may be an indication that the change in shape (21.43%) does not appear to be effective when it comes to obtain children's attention visually. This could indicate that the use of visual elements based on size and color may be more suitable to capture the initial attention of kids when compared to shape.

***b) Test of color perception - "Seven Errors Game":*** the children found the errors faster in the black and white image (average of 06 seconds per error) as compared to the colored image (average of 16 seconds/error). This seems to indicate that the variable color does not contribute positively in complex situations that require concentration to solve a problem. Within the time frame of the test, children found an average of 5 errors in the color image, and 6 errors on the black and white image. It was observed that the percentage of children who failed to complete the task is quite high, which may indicate that an activity that requires a higher level of concentration may not be suitable for classroom learning situations, such as using a 7 errors game for teaching vocabulary.

***c) Perception test - Color, Shape and Size - "Connect the Dots Game":*** the results show that there is a greater effectiveness for simpler shapes (100% for an apple; 55% for a vase and 50% for the butterfly) and such effectiveness does not change, independently of the variable (color, shape, size) used. It was found that the shape played a dominant role over the variables tested. Could it be the case that the children were able to complete (better) the objects they already knew? Another suspicion is the lower level of intellectual development.

About efficiency (time in seconds), it's possible to conclude that there is a similar result to the effectiveness of the activity, with greater difficulty for the figure with more complex features (more dots and greater complexity of form) and a greater difference than in the comparison between same items for the effectiveness (124,3s to the apple; 155,33s to the vase and 274s to the butterfly). The results obtained for each of the visual variables may also indicate that when varying the shape of the dots to be connected it's possible to minimize the use of a difficult figure (in this case, the butterfly).

***d) Subjective preferences test - Variable Color:*** results show the subjectivity of this type of verification. If we consider only the primary colors, the results may be a confirmation that children who are beginning primary school prefer the colors in the following order: red (30.77%), yellow and green.

The proposed environment was validated as per the case study presented. The results show that the use of the environment within the school (as opposed to a lab setting) helped in making the children at ease as subjects. One must remember that most of these children have been through a lot of medical and psychological tests, due to their Deafness, and are, thus, very adamant to take yet another clinical test.

The case study allowed the researchers to improve on the environment: for example, a correction was made to the time allotted for completion of each task, based on the average. Additionally, the environment was designed for a group setting, but it was observed that what was happening with their colleagues distracted the children. The eraser was added to the test, as per request of the children during the "link the dots" test.

## 4 Conclusion and Future Works

The Deaf community has been denied basic citizenship rights. HCI should make the effort to better understand their needs to inform design. The present research aims at better understand the way the Deaf perceives visual information. Such goal is achieved by the proposal of a testing environment that respects the Deaf´s particularities. The four tests presented in the environment are ludic in manner, thus avoiding the hard testing done in labs. A case study validated the adequacy of the environment, in a classroom setting, for the target audience. The results of the case study are a strong indication that the incorporation of futures specific for the Deaf (e.g. video, Sign Language etc.) is paramount for a better design of such tests. For example, they contributed to a willing participation of the Deaf. Color, shape and size were the visual variables assessed. The case study allowed for some minor corrections to the environment.

Although the case study validated the environment in its adequacy for the Deaf culture, it is fair to say that this validation does not extend to the tests themselves. Such validation of the tests requires extensive test-validation, to be performed in future work. Brazil is a continental country, and the subjects needed for this validation are geographically sparse, which renders the work difficult. The online environment will help the researchers to perform the validation remotely.

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